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TITLE

**ELECTRON-EMITTING DEVICE,  
ELECTRON SOURCE,  
AND IMAGE-FORMING APPARATUS**

RELATED APPLICATIONS

This application is a division of Application No. 09/332,101, filed June 14, 1999, which is a division of Application No. 08/264,497, filed June 23, 1994, <sup>now U.S. Patent No. 6,169,356</sup>

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to an electron source and an image-forming apparatus such as a display apparatus incorporating an electron source and, more particularly, it relates to a novel surface conduction electron-emitting device as well as a novel electron source and an image-forming apparatus such as a display apparatus incorporating such an electron source.

Related Background Art

[0002] There have been known two types of electron-emitting devices; the thermoelectron type and the cold cathode type. Of these, the cold cathode type

[0016] According to another aspect of the invention, there is provided a method of manufacturing an electron-emitting device comprising a pair of oppositely disposed electrodes and an electroconductive film arranged between the electrodes and including a high resistance region, characterized in that it comprises a step of activating the device.

[0017] According to still another aspect of the invention, there is provided an electron source comprising an electron-emitting device for emitting electrons as a function of input signals characterized in that said electron-emitting device is produced with the above described method.

[0018] According to a further aspect of the invention, there is provided an image-forming apparatus comprising an electron source and an image-forming member for forming images as a function of input signals characterized in that said electron source comprises an electron-emitting device that is produced with the above described method.

[0019] Now, the present invention will be described in greater detail by referring to the accompanying drawings that illustrate preferred embodiments of the invention.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Figs. 1A and 1B are schematic plan and sectional side views showing the basic configuration of a flat type surface conduction electron-emitting device according to the invention.

[0021] Figs. 2A through 2C are schematic side views showing different steps of a method of manufacturing a surface conduction electron-emitting device according to the invention.

[0022] Fig. 3 is a block diagram of a gauging system for determining the performance of a surface-conduction type electron-emitting device according to the invention.

[0023] Figs. 4A through 4C are graphs showing voltage waveforms observed during an electrically energizing process conducted on a surface conduction electron-emitting device according to the invention.

[0024] Fig. 5 is a graph showing the relationship between the device current and the time of activation process.

[0025] Figs. 6A and 6B are schematic sectional views showing an embodiment of surface conduction electron-emitting device according to the invention before and after an activation process respectively.

[0026] Fig. 7 is a graph showing the relationship between the device voltage and the device current as well as the relationship between the device voltage and the emission current of an embodiment of surface conduction electron-emitting device according to the invention.

[0027] Fig. 8 is a schematic plan view of the substrate of an embodiment of electron source according to the invention used in Example 2 as described hereinafter, showing in particular the simple matrix configuration of the substrate.

[0028] Fig. 9 is a schematic perspective view of the substrate of the embodiment of electron source of Fig. 8.

[0029] Figs. 10A and 10B are enlarged schematic plan views of two different fluorescent layers that can be used alternatively for the embodiment of Fig. 8.

[0030] Fig. 11 is a plan view of the electron source used in Example 1 as described hereinafter.

[0031] Fig. 12 is a block diagram of the system used for the activation process of Example 3 as described hereinafter.

[0032] Fig. 13 is an enlarged schematic partial plan view of the substrate of the electron source of an embodiment of image-forming apparatus according to the invention used in Example 2 as described hereinafter.

[0033] Fig. 14 is an enlarged schematic sectional side view of the substrate of Fig. 13 taken along line A-A'.

[0034] Figs. 15A through 15D and 16E through 16H are schematic partial sectional side views of the substrate of Fig. 13, showing different steps of the method of manufacturing the same.

[0035] Figs. 17 and 18 are schematic plan views of two different substrates of electron source alternatively used in the image-forming apparatus of Example 9.

[0036] Figs. 19 and 22 are schematic perspective views of two different panels alternatively used in the image-forming apparatus of Example 9.

[0037] Figs. 20 and 23 are block diagrams of two different electric circuits alternatively used to drive the image-forming apparatus of Example 9.

[0038] Figs. 21A through 21F and 24A through 24I are two different sets of timing charts alternatively used to drive the image-forming apparatus of Example 9.

[0039] Fig. 25 is a block diagram of the display apparatus of Example 10.

[0040] Fig. 26 is a schematic side view of an embodiment of step type surface conduction electron-emitting device according to the invention.

[0041] Fig. 27 is a schematic plan view of a conventional surface conduction electron-emitting device.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0042] Now, the present invention will be described in terms of preferred embodiments of the invention.

[0043] The present invention relates to a novel surface conduction electron-emitting device, a method of manufacturing the same and a novel electron source incorporation such a device as well as an image-forming apparatus such as a display apparatus incorporating such an electron source and applications of such an apparatus.

[0044] A surface conduction electron-emitting device according to the invention may be realized either as a flat type or as a step type. Firstly, a flat type surface conduction electron-emitting device will be described.

[0045] Figs. 1A and 1B are schematic plan and sectional side views showing the basic configuration of a flat type surface conduction electron-emitting device according to the invention.

[0046] Referring to Figs. 1A and 1B, the device comprises a substrate 1, a pair of device electrodes 5 and 6, a thin film 4 including an electron-emitting region 3.

[0047] Materials that can be used for the substrate 1 include quartz glass, glass containing impurities such as Na to a reduced concentration level, soda lime glass,